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(54) Title of Invention: Plasma Processing Device

(57) Abstract

[Purpose] To achieve a uniform, high-density, plasma in a plasma processing device using the inductive coupling method.

[Configuration] In a plasma processing device wherein the plasma is generated by applying high frequency electric power to flat plate coil unit 13, that is juxtaposed with processing object 6, and then said plasma is used for processing the aforementioned processing object, the aforementioned flat plate coil unit consists of a multiple number of coils 14, 15, 16 and 17, electric current control means 18 is connected to each of these multiple number of coils, or additional coils are connected in parallel with respect to the high frequency electrical power supply; and by configuring the flat plate coil unit with a multiple number of coils, it becomes possible to increase the magnetic flux density without increasing the impedance, achieving a uniform distribution of the magnetic flux density, and control of the electric current that is supplied to each coil, as well as controlling the conditions of magnetic flux that has been generated on each coil, thereby contributing to the generation of a uniform high density plasma.

[Schematic on the right]

[Claims]

[Claim 1] In a plasma processing device wherein plasma is generated by applying high frequency electric power to the flat plate coil unit, that is juxtaposed with the processing object, and then said plasma is used for processing the aforementioned processing object, a plasma processing device characterized by the aforementioned flat plate coil unit consisting of multiple numbers of coils.

[Claim 2] The plasma processing device described in Claim 1 wherein an electrical current control means is connected to each of a multiple numbers of coils.

[Claim 3] The plasma processing device described in Claim 1 wherein multiple numbers of coils are connected in parallel to a high frequency power supply.

[Detailed Explanation of the Invention]

[0001]

[Field of Industrial Utilization] The present invention is related to a plasma processing device wherein plasma is generated by supplying high frequency electrical

power through an inductive coupling and said plasma is used for purpose of manufacturing semiconductor devices.

[0002]

[Prior Art] There are both the static electrostatic capacity coupling method and the inductive coupling method for supplying a vacuum container with high frequency electrical power in order to generate and energize the plasma. In recent years, substantial processing capacity has been called for by the semiconductor manufacturing device and for various processing device that use plasma, such as a LCD, thereby requiring a higher concentration of generated plasma.

[0003] In a typical configuration of the plasma processing device that uses the aforementioned electrostatic coupling method, high frequency electrical power is applied [to the area] between the parallel, flat plate electrodes that are juxtaposed across from each other, and the high energy ions and electrons in the plasma reach the processing object due to a high frequency electrical field consisting of plasma that has been generated between the parallel flat plate electrodes, thereby causing damage to the processing object, as well as unavoidable contamination from the electrodes.

[0004] On the other hand, as disclosed in Patent Application No. H1-338900, a plasma processing device that uses an inductive coupling method has an advantage, in that less damage to the processing objects is caused by the electrons and ions, contributing to a substantial improvement in the processing capacity due to the low energy of the ions, and electrons that are restrained by magnetic flux, thereby facilitating greater production of high density plasma.

[0005] In Figures 4 and 5, a plasma processing device using an inductive coupling method based on prior art is described.

[0006] A metal vacuum container 1 is provided, then cover 2, which is made of a material having permeability, such as quartz, that covers both the interior wall and the ceiling of aforementioned vacuum container 1, is fitted in aforementioned vacuum container 1. Flat coil 3 is placed on top of the ceiling of said cover 2, one end of said coil 3 is connected to the first high frequency power supply 4 while the other end, thereof, is grounded. On bottom plate 5 that closes the bottom side of aforementioned vacuum container 1 to provide an airtight seal, processing platform 7 is provided,

juxtaposed with aforementioned coil 3, in order to place processing object 5 thereupon; the aforementioned processing platform is connected to second high frequency electrical power supply 8.

[0007] The high frequency electrical power is provided to the aforementioned coil 3 from first high frequency electrical power supply 4, and plasma is generated within cover 2 through the inductive coupling, thereby providing said plasma with high frequency energy. As the plasma generated through the inductive coupling lacks anisotropy, a high frequency bias is generated by applying high frequency electric power to the aforementioned processing platform 7 from aforementioned second high frequency electric power supply 8. Thus, the aforementioned processing object 6 is etched by ions from the plasma.

[0008]

[Problems to be Solved by the Invention] However, as the plasma processing device using the aforementioned inductive coupling method of prior art employs coil 3 that has been formed into a flat spiral form, it is necessary to determine the appropriate shape of the coil and the number of turns, thereof, with respect to the shape of vacuum container 1, size of the processing object 6, and the correlation between vacuum container 1 and processing object 6, in order to achieve a uniform concentration of the plasma that has been generated on said coil 3, thereby requiring numerous repeated experiments for each production to ascertain the shape and number of turns of the coil.

[0009] Furthermore, when deciding the specifications of the coil, the impedance increases as the number of turns of the coil increases, thereby requiring higher voltage to attain the necessary high frequency electrical current; it is, therefore, difficult to maintain electrical isolation between the corresponding high frequency electrical power supply device and the coiled terminals. Consequently, the high frequency electrical power supply device becomes inevitably expensive.

[0010] Moreover, as the size of vacuum container 1 increases, the inductance of the spiral coil further increases. Consequently, reducing the number of turns leads to a magnetic flux density distribution that corresponds to the shape of a flat plate coil, thereby resulting in a greater density distribution gap. Plasma oscillation occurs as plasma density distribution corresponds to said magnetic flux density distribution,

contributing to an unstable plasma. This is attributed to problems such as the accumulation of electrons on the processing object, or uneven film quality when creating a thin film on processing object 6.

[0011] By taking such conditions into considerations, the present invention is an attempt to more easily generate a more uniform, high density plasma in a plasma processing device using the inductive coupling method.

[0012]

[Means to Solve Problems]

The present invention involves a plasma processing device wherein plasma is generated by applying a high frequency electric power to the flat plate coil unit that is juxtaposed with the processing object, and said plasma is used for processing the aforementioned processing object, characterized by the aforementioned flat plate coil unit consisting of multiple number of coils, an electric current control means being connected to each of the additional coils, or additional coils being connected in parallel with respect to the high frequency electrical power supply.

[0013]

[Operations] By configuring the flat plate coil unit with multiple coils, it becomes possible to increase the magnetic flux density without increasing the impedance, achieve a uniform distribution of the magnetic flux density, and control the electric current that is supplied to each coil, as well as controlling the conditions of the magnetic flux that has been generated on each coil, thereby contributing to the generation of uniform, high density, plasma.

[0014]

[Embodiments] An embodiment of the present invention is described below by referring to the drawings.

[0015] On the bottom of vacuum container 10, processing platform 11 is provided in an air tight condition, and processing object 6 is loaded on to said processing platform 11. The ceiling of aforementioned vacuum container 10 consists of ceiling plate 12 made of an insulating material such as quartz, glass, or analuna*1 ceramics, and flat plate coil unit 13 is installed on the top surface of said ceiling plate 12.

[0016] Said flat plate coil unit 13 consists of a multiple number of flat plate coils 14, 15, 16, and 17; each of coils 14, 15, 16, and 17 is positioned on the fan-shaped plane that is formed by dividing ceiling plate 12 into quarters and is connected, via variable capacitor 18, to the first high frequency electrical power supply 19 in parallel. The aforementioned processing platform 11 is grounded through switch 20, while the aforementioned processing platform 11 is connected, via DC blocking capacitor 21, to second high frequency electrical power supply 22.

[0017] In the diagram, 23 is a gas inlet to introduce a gas for purpose of processing, and 24 is an exhaust outlet.

[0018] The high frequency electric power is supplied to aforementioned flat plate coil unit 13 from first high frequency electric power supply 19 to generate plasma in vacuum container 10 by inductive coupling, thereby supplying a high frequency energy to said plasma.

[0019] The aforementioned processing platform 11 is grounded by turning on switch 20 based on the intention to process processing object 6, or high frequency bias is applied from second high frequency power supply 22.

[0020] More specifically, a required thin film is created on processing object 6 if [the processing platform is] grounded by turning on switch 20, while the etching process is executed over the thin film that has been formed on processing object 6 if high frequency bias is applied thereto from second high frequency electrical power supply 22.

[0021] The inductance values, as well as the plasma coupling level, slightly differ among aforementioned coils 14, 15, 16, and 17. The aforementioned inductance value and plasma coupling level may be controlled by regulating the capacitance for aforementioned variable capacitor 18 and varying the electrical current that is supplied to aforementioned coils 14, 15, 16, and 17, thereby achieving a uniform plasma density within the aforementioned vacuum container 10.

[0022] Additionally, as described earlier, aforementioned flat plate coil unit 13 becomes larger as the size of vacuum container 10 increases; however, impedance is reduced as said flat plate coil unit 13 consists of multiple numbers of coils 14, 15, 16, and 17. The impedance is further reduced as coils 14, 15, 16 and 17 are connected in parallel. As a result, it becomes possible to control plasma oscillation caused by reduced impedance. Argument 2

[0023] Furthermore, the intensity of the magnetic flux that is generated by coils 14, 15, 16, and 17 may be adjusted by measuring the density of the plasma in vacuum container 10 in order to control the electrical current that is supplied to aforementioned coils 14, 15, 16, and 17 at the aforementioned variable capacitor 18, thereby achieving uniformity in the magnetic flux density formed by entire flat plate coil unit 13. Stable, uniform plasma is thus obtained without distortion being caused by the plasma.

[0024] There are various methods available for dividing flat plate coil unit 13, as well as the arrangement of coils; for example, a circular coil is placed in the center as shown in Figure 3, and arc-shaped coils are placed to surround [said circular coil].

[0025] Moreover, a means to control the electrical current may be used as the aforementioned variable capacitor 18; a variable resistance, coil, or a combination thereof may also be used.

[0026]

[Effect of the Invention] According to the present invention, as described above, impedance may be reduced without generating density variances in the magnetic flux distribution as the flat plate coil unit consists of multiple numbers of coils, thereby resulting in superior effects such as controlling plasma oscillation and easily generating uniform, high density plasma by controlling the electrical currents supplied to each coil.

[Brief Explanation of Drawings]

[Figure 1] Schematic cross-sectional view of an embodiment of the present invention.

[Figure 2] Schematic plane view of the embodiment of the same.

[Figure 3] Schematic plane view of another embodiment of the present invention.

[Figure 4] Schematic cross-sectional view of a prior art.

[Figure 5] Schematic plane view of the schematic cross-sectional view of the same prior art.

[Legend]

6 Processing object

10 Vacuum container

13 Flat plate coil unit

14 Coil

説明する。

【0015】真空容器10の底部には処理台11が気密に設けられ、該処理台11には被処理物6が装填される。前記真空容器10の天井は石英、ガラス、及びアナルナセラミックス等の絶縁材料から成る天井板12で構成され、該天井板12の上面に平板コイルユニット13を載設する。

【0016】該平板コイルユニット13は複数の平板コイル14，15，16，17により構成され、各コイル14，15，16，17は天井板12を4分割した扇形状の各平面内に配設され、それぞれ可変コンデンサ18を介して第1高周波電源19に並列接続されている。前記処理台11はスイッチ20を介して接地され、又前記処理台11は直流阻止コンデンサ21を介して第2高周波電源22に接続される。

【0017】図中、23は処理用のガスを導入するガス導入口、24は排気口である。

【0018】第1高周波電源19より前記平板コイルユニット13に高周波電力を供給し、誘電結合により真空容器10内にプラズマを発生させ、該プラズマに高周波エネルギを供給する。

【0019】前記処理台11は被処理物6を処理する目的に応じてスイッチ20をONして接地し、或は第2高周波電源22より高周波バイアスが印加される。

【0020】即ち、スイッチ20をONして接地した場合は、被処理物6に所要の薄膜が生成され、又第2高周波電源22より高周波バイアスが印加された場合は被処理物6に成膜された薄膜のエッチングが行われる。

【0021】前記コイル14，15，16，17はそれぞれ微妙にインダクタンス値、プラズマ結合程度が異なる。前記可変コンデンサ18の静電容量値を調整し、前記コイル14，15，16，17に流れる電流を変えることで、前記インダクタンス値、プラズマ結合程度を調整することができ、前記真空容器10内のプラズマ密度を均一にできる。

【0022】更に、上記した様に真空容器10の寸法が大きくなると、前記平板コイルユニット13が大きくなるが、該平板コイルユニット13は複数のコイル14，15，16，17によって構成されているのでインピーダンスが低下し、更に複数のコイル14，15，16，17を並列接続することで更にインピーダンスが低下する。而して、インピーダンス低下に起因するプラズマ振動を抑制できる。

【0023】更に又、真空容器10内のプラズマ密度を測定して前記コイル14，15，16，17に流れる電流を前記可変コンデンサ18で調整することで、複数のコイル14，15，16，17により発生する磁束強度を調整することができ、平板コイルユニット13全体が形成する磁束密度を均一化することができる。而して、プラズマが乱れず安定な且均一なプラズマが得られる。

【0024】尚、平板コイルユニット13の分割方法、コイルの配列は種々考えられ、例えば図3に示す様に中央に円状のコイルを配設し、その周囲に円弧状のコイルを配設する等である。

【0025】又、前記可変コンデンサ18は電流を調整する手段であればよく、可変抵抗、コイル或はこれらの組合わせでもよい。

【0026】

【発明の効果】以上述べた如く本発明によれば、複数のコイルにより平板コイルユニットを構成しているので、磁束分布に粗密の差を発生することなくインピーダンスの低下が可能であり、プラズマ振動を抑制できると共に各コイルに供給する電流を調整することで均一な高密度プラズマが容易に得られる等の優れた効果を発揮する。

【図面の簡単な説明】

【図1】本発明の一実施例を示す概略立断面図である。

【図2】同前実施例の概略平面図である。

【図3】本発明の他の実施例を示す概略平面図である。

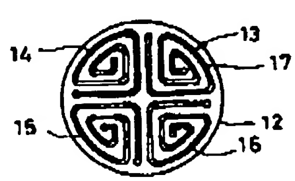
【図4】従来例を示す概略立断面図である。

【図5】同前従来例の概略平面図である。

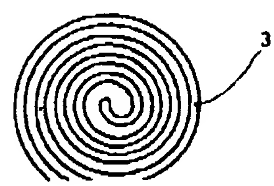
【符号の説明】

6	被処理物
10	真空容器
13	平板コイルユニット
14	コイル
15	コイル
16	コイル
17	コイル
18	可変コンデンサ
19	第1高周波電源
22	第2高周波電源

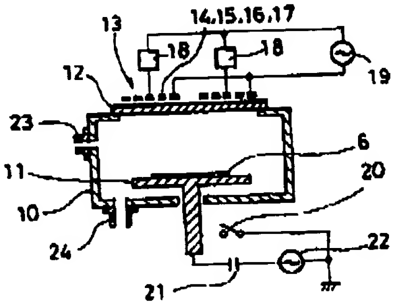
【図2】



【図5】



【図1】



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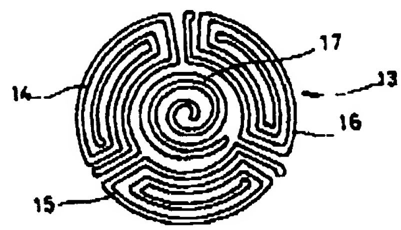
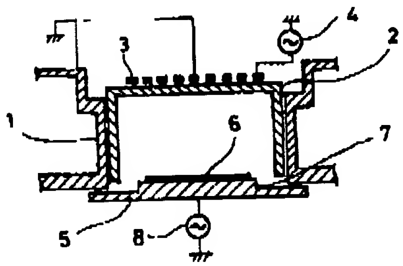


【図4】



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(51)Int.Cl.^{6}	識別記号	庁内整理番号	F I	技術表示箇所
H01L 21/31		C		

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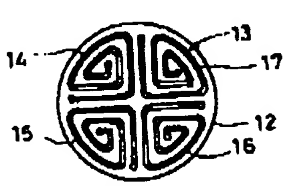
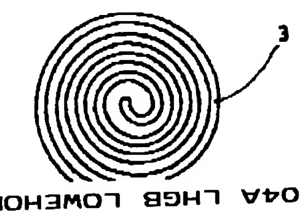
【図2】



【図5】



15 Coil

16 Coil

17 Coil

18 Variable capacitor

19 First high frequency electrical power supply

22 Second high frequency electrical power supply

[Figure 2] [Figure 5]

[Figure 1] [Figure 3]

[Figure 4]

Continued from the front page

(51) Int. Cl.6	Classification No.	Intraoffice Filling No.	FI	Technology displayed area
H01L 21/31			C	

Translator's note *1: Transliterated as the translator was unable to locate the correct spelling for this word.